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ARRESTING THE MOVING SLOPES OF ANDAMANS

- A CASE STUDY

Paper No 2.51L

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ABSTRACT

Some cases of soil erosion, slope instability, mass movement of soil and damage to structures were observed in Navy and Coast Guard Area of Port Blair. Field and laboratory tests in the area were carried out which revealed that the area is unstable and prone to landslides. Main causes of instability are soil characteristics and poor subsoil drainage conditions. Some preventive measures, in the past were taken which have achieved limited success. Additional solutions based on latest technology and construction materials are suggested which shall be economical and eco-friendly.

KEYWORDS

Eco- friendly, erosion control, geotextile, instability of slopes, land slides, soil reinforcement, stability analysis.

INTRODUCTION

Andaman and Nicobar Group of Islands in India are located at a distance of approximately 1600 Km from the main land. There are more than 500 islands in this group out of which only 36 are inhabited. While the volcanic eruption of Barren Island here (which is still alive), had diverted the attention of geologists world over, the movement of slopes in Navy and Coast Guard Area in Port Blair where some structures have experienced damages (Fig. 1), retaining walls have moved to an extent of 4 to 6 meters in a period of last about 10 years (Fig. 2), the roads have suffered subsidence and structures like septic tanks and culverts as a whole have shifted and moved down by more than a meter due to mass movement of the slopes, has diverted the attention of Geotechnical engineers in the country.

Some protective measures in the area have been taken in the past to arrest the unstable slopes. These could however achieve limited success. This paper describes the problem of soil erosion and slope instability observed in Port Blair, critically examines the measures undertaken in the past and recommends the additional measures to be adopted in the field based on latest soil investigations and available echnology and materials which shall be economical and eco-friendly.

INSTABILITY OF SLOPES

During 1980s a number of buildings were constructed in Coast Guard and Navy Area of Port Blair by cutting and leveling the hillocks. The roads, drains and retaining walls formed part of this construction. Most of construction work came up very close to the Coast Line due to defence requirements, restriction on availability of land, and for the requirement of scenic view. As the area consisted of steep slopes, the slope protection measures were necessary to retain the slopes.

As the construction activities progressed in the area, subsidence of hill slopes in some places were noticed. A portion of the retaining wall in Naval Officers Mess Area moved by about 4 to 7 cm in 1984 during rains. In next monsoon the wall moved more than 90 cm despite reducing the earth fill behind it. Till date, this wall has moved more than 6 m from its original location along with the soil surrounding it (Figs 3).

Other signs of distress and slope movement in this area are shown by the tilted and damaged building shown in Fig 1 which had to be abandoned very soon after is construction. A land slides in the same area also occurred damaging the roads.

During 1991 another retaining wall in Coast Guard area showed movement and the road leading to proposed Coast Guard Jetty area was badly damaged.

SOIL INVESTIGATION

Field and laboratory investigations in the area were carried out. The Engineering properties of soil collected from four different bore holes in the area are as shown in Table 1.
On the basis of grain size analysis the soil is observed to be silty sand and clayey silt. The index properties of the soil indicated that the soil can be classified as CI and CH types i.e. inorganic clays of medium and high plasticity as per IS specification. Water content under load of 400 kN/Sq. m was observed to be equal to plastic limit of the soil.

Table 1

Engineering Properties of Soil

Location	Depth (m)	LL	PI	Gr.	Sand	Silt	Clay	Shear Strength Parameters	
								c' kN/Sq.m	ϕ' Deg
BH-A	0-1.25	40	16	3	23	51	23	2	28
	1.25-2.5	38	16	4	21	52	23	4	27
BH-B	0-1.25	54	29	6	10	48	36	3	23
	1.25-2.5	53	30	3	18	49	30	4	22
BH-C	0-1.25	43	19	9	22	53	16	2	26
	1.25-2.5	44	20	15	10	60	15	2	25
BH-D	0-1.25	54	29	9	26	36	29	2	22
	1.25-2.5	52	27	6	17	48	29	3	23

STABILITY ANALYSIS

The stability analysis of five slopes profiles in the area was carried out by using a computer program based on Bishop's Method of slices. In each of the profiles the critical section were identified viz. section where shifting retaining walls, damaged buildings and structures are located and where slopes are steep. The sections are analysed under different conditions of piezometric levels starting from ground level to lower depths. The slip circles with least factor of safety were identified in each case and piezometric levels corresponding to which slopes are stable, is determined. The results of two such profiles are summarised in Table 2.

The following conclusions are drawn from the above investigations and stability analysis :

1. The area experiences heavy rains and soil is moist in most parts of the year.

2. During rainy seasons the water table rises almost to the ground surfaces due to continuos heavy rains.

3. Quite a few number of slopes in the area are unstable (factor of safety less than 1.0) when water table is at the surface which is the case during monsoons.

4. Factor of safety rapidly increases with lowering of the water table.

5. Most of the slopes become stable when water table is lowered 1 meter below the ground surface and cohesion of soil is improved to 5 kN/Sq.m.

6. In a few slopes (where land slide have occurred), the slopes are unstable even after lowering the water table 1 m below the ground level.

Assuming that the water table in the areas can not be lowered further than 1 m below the surface, the soil cohesion was increased to check at what value of cohesion the slope will be stable. It was observed from the results that a cohesion value of 10 to 15 could make these slopes stable.

Table 2

Factor of Safety for Various Piezometric levels

Profile	Section	Depth of Water Table (m) from Surface				Remarks
		0	0.2	0.5	1.0	
I	1	0.56	-	1.15	1.36	
	2	0.43	-	0.67	0.81 (1.21)*	* for c=5
	3	0.8	1.5	-	-	
II	1	0.45 (0.63)*	-	0.61	0.7 (1.02)* (1.25)**	* for c=5
	2	0.35 (0.64)*		0.63 (0.76)*	0.74 (0.83)* (0.93)** (1.01)***	**for c=10 ***for c=15

STABILISATION MEASURES

Based on the above conclusion it is revealed that improvement of subsoil drainage to keep the water table at least 1 m below the surface and improving the cohesion of the soil are two important factors in stabilisation of slopes in this area. The details of repair to a hill slope carried out in 1994 where road was damaged due to land slide in Buniyadabad Area is shown in Fig 5. The successive stone crate protection with bamboo piling in the soil were aimed at achieving better cohesion and subsoil drainage in the area. This type of repair work has been observed quite satisfactory over last two years. The slope has stabilised and sufficient greenery and vegetation has also come out in the area.

APPLICATION OF GEOSYNTHETICS

Geosynthetic materials can be advantageously used in the area both in improving the horizontal and vertical sub soil drainage as well as by reinforcing the soil with concept like reinforced soil wall. The jute based geotextile and other geomats and geogrids may be gainfully utilised for promotion of growth of vegetation on natural and man made slopes in the area. A method of stabilisation of slopes by use of jute based geotextile has been used in the area for stabilisation of road side slope as shown in Fig 4.

Fig 1. Tilted and Damaged Building due to Subsidence and Mass Movement

Fig 2 Shifting of retaining Wall and Tilting of Tree due to Movement of Soil Mass

Fig 3. Movement of Another Retaining Wall Near Naval Officer's Mess

Fig 4. Repair to Slope Near Road Embankment By Jute Based Geotextile

Fig. 5 Repair to Slope by Bamboo Piling and Stone Crates in Buniyadabad Area in 1994.

CONCLUSION

From the above discussion it is concluded that the improvement of the subsoil drainage system and improving the soil cohesion by soil reinforcement are the solution to stabilise the slopes in the Area in addition to providing suitable protection to the coast line from Sea erosion. The local materials like bamboo piling, geotextile and gesynthteic materials must be gainfully exploited in the area due to their economic and eco-friendly characteristics. The best way for looking after the precious soil in these islands is, ***'Don't Waste it, Don't Replace it, But Reinforce it'.***

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